UDC 666.3-431

IMPROVEMENT OF FACING BRICK PRODUCTION

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Translated from Steklo i Keramika, No. 5, pp. 28 – 29, May, 2000.

The results of studying argillaceous materials from the Malo-Budishchanskoe deposit (Poltava Region) used in the production of face brick are described. It is demonstrated that the introduction of kaolinite-hydromica clays into the ceramic mixture composition makes it possible to improve the technological and physicomechanical properties of the mixtures, as well as increase the strength of the finished products.

Facing brick is produced at the Malo-Budishchanskii Experimental Factory of Construction Materials (Poltava Region) using the slip casting method. The raw material of the Malo-Budishchanskoe deposit is loam of low or medium plasticity which is arranged in three layers. The first layer (2.7 – 4.7 m thick) has yellow-brown loam with plasticity number 7.3 – 6.2 and carbonate inclusion content up to 2%. The second layer (2.3 – 6.2 m thick) contains pale yellow loam with plasticity number equal to 4.1 – 6.2 and carbonate inclusion content up to 1.8%. The third layer about 4.6 m thick contains dark brown loam which in its plasticity and chemical composition is close to the yellow-brown loam of the first layer.

According to the content of carbonate inclusions, the deposit is divided into two strata: the calcium content in the first stratum is on the average 0.53 – 0.84%, and in the second stratum 2 – 3%. Tables 1 and 2 present the chemical and granulometric content of the raw material from the Malo-Budishchanskoe deposit.

In order to obtain reliable data for prediction and development of expedient ceramic mixtures, the mineral composition of the Malo-Budishchanskoe clay was studied using thermal and x-ray phase analysis performed at the Ukrainian Research and Design Institute of Construction Materials and Products (NIISMI). Analyzing the obtained data, it can be noted that the clay in all three layers is polymineral, carbonized, and contains a substantial amount of organic materials and quartz.

According to the x-ray phase data, the first layer contains quartz, montmorillonite, mica, kaolinite, and feldspar, the second layer contains quartz, montmorillonite, kaolinite, feldspar, and calcite, and the third layer includes quartz, montmorillonite, kaolinite, mica, feldspar, and carbonates.

The differential heating curve of the first layer clay is characterized by the following thermal effects: endothermic effects at temperatures 140 and 220°C (release of interlayer water), a wide exothermic effect at temperature 280 – 480°C (burning out of the organic component), an endothermic effect at 550 – 560°C (decomposition of argillaceous materials), endothermic effects at 660 and 770°C (dissociation of carbonates), and a slight exothermic effect at 900°C (crystallization of the argillaceous compound).

The heating curve of the second layer is virtually similar to the heating curve of the first layer. However, one should note the presence of endothermic effects at temperatures of 570°C (polymorphous transformation of quartz) and 850°C (decomposition of calcium carbonate).

The differential heating curve of the third layer is similar to the heating curve of the first layer.

Analysis of the chemical composition of the clays indicates that the content of most oxides affecting the physicochemical properties and water absorption of finished goods

TABLE 1

Layer	Mass content, %									
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	SO_3	Na_2O	K_2O	Calcination loss
First	68.54	11.25	4.43	0.70	4.40	1.22	0.27	0.74	1.96	6.58
Second	66.99	8.07	2.72	0.58	8.77	1.22	0.27	0.63	1.88	8.94

TABLE 2

Layer	Content, %, of particles sized, mm					
	0.25	0.25 – 0.05	0.05 – 0.01	0.01 – 0.005	0.005 – 0.001	0.001
First	0.13	5.62	52.45	13.25	20.00	8.55
Second	0.12	1.23	66.75	11.50	14.35	6.05

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0361-7610/00/0506-0177$25.00

TABLE 3

Mixture	Clay content, %, from deposit				
	Malo-Budishchanskoe			Artemovskoe	Kirovogradskoe
	first layer	second layer	third layer		
P1	100	–	–	–	–
P2	–	100	-		-
P3	·	–	100	–	–
P4	35	30	35	–	–
P5	28	24	28	20	–
P6	28	24	28	–	20
P7	50	–	50	–	–

TABLE 4

Sample of mixture	Moisture, %		Drying sensitivity coefficient, sec	Total shrinkage	Compression strength, MPa	Water absorption, %
	absolute	relative				
P1	9.7	8.84	92	0.6	12.8	15.4
P2	11.0	10.00	62	0.2	11.7	19.4
P3	9.5	8.67	77	0.8	10.4	15.0
P4	9.4	8.59	76	0.5	13.5	20.2
P5	9.2	8.42	80	0.2	25.7	16.2
P6	12.7	11.27	168	0.2	27.8	15.3
P7	10.6	9.60	157	0.8	22.8	17.7

varies over a wide range. Thus, the SiO_2 content varies from 66.99 to 68.54%, Al_2O_3 from 8.07 to 11.25%, and CaO from 4.40 to 8.77%. Modifications of the chemical composition of the initial materials are caused by the nonuniformity in the arrangement of the layers, incorporation of the lower layer lenses into the upper layers, and insufficient control of bed mining and mixture preparation.

Specific features of the brick production technology include heating the mold up to 70°C, as well as combined drying and firing of molded bricks in a tunnel furnace which has three sections: preparation (drying), firing, and cooling zones. Since the percentage of defective articles in brick production is high, due to the imperfection of the existent press machines, NIISMI has carried our research to improve the molding properties of the material, as well as increase the compression strength of finished articles. This is accomplished by introducing high-melting Artemovskoe and Kirovogradskoe clays to ceramic mixtures. The above clays by their mineralogical composition are kaolinite-hydromica materials and can act as efficient additives to polymineral clays.

In order to select the optimum batch compositions, the technological properties of mixtures whose compositions are listed in Table 3 were investigated.

The mixture components were prepared using the dry method: the materials were dried at temperatures 100 – 110°C up to complete moisture removal, then crushed in a jaw crusher and in laboratory dry grinding mills until passing through a sieve with 3 mm cell size. The granulometric composition of the crushed material was determined by sifting it through sieves with cells of sizes 3, 2, 1, and 0.5 mm. The ceramic mixture components were thoroughly mixed with water until getting a homogeneous mixture with the required molding moisture. Cylindrical-shaped laboratory samples 56.1 in diameter and 50.0 mm high were molded by the semidry method on a MP-1000 hydraulic press.

The technological and physicomechanical properties of the mixtures were measured under the optimum molding moisture content for each specific mixture (Table 4). The samples were molded under 20 MPa pressure, and fired under 1050°C temperature. The heating rate was 70 K/h, and the curing at the final temperature lasted 3 h.

As can be seen, the loams from the Malo-Budishchanskoe deposit belong to the category of drying-sensitive material (less than 100 sec). Upon the introduction of kaolinite-hydromica clays, which are insensitive to drying (above 180 sec) in the amount of 20%, mixtures with medium sensitivity to drying were obtained. Mixtures with these additives have minimum shrinkage (0.2%). The highest strength is exhibited by samples of mixture P6 (27.8 MPa). The water absorption of the mixtures varies insignificantly and amounts to 15.0 – 20.0%.

Adding kaolinite-hydromica clays to the Malo-Budishchanskoe deposit loams improves their technological and physicomechanical properties, the best results being registered in mixture P6 based on Malo-Budishchanskoe deposit with Kirovogradskoe clay additive.

Thus, by modifying the ratio of argillaceous rock-forming minerals in the initial mixture composition through the introduction of argillaceous material of various mineralogical compositions, it is possible to control the physicotechnical parameters of the fired products.